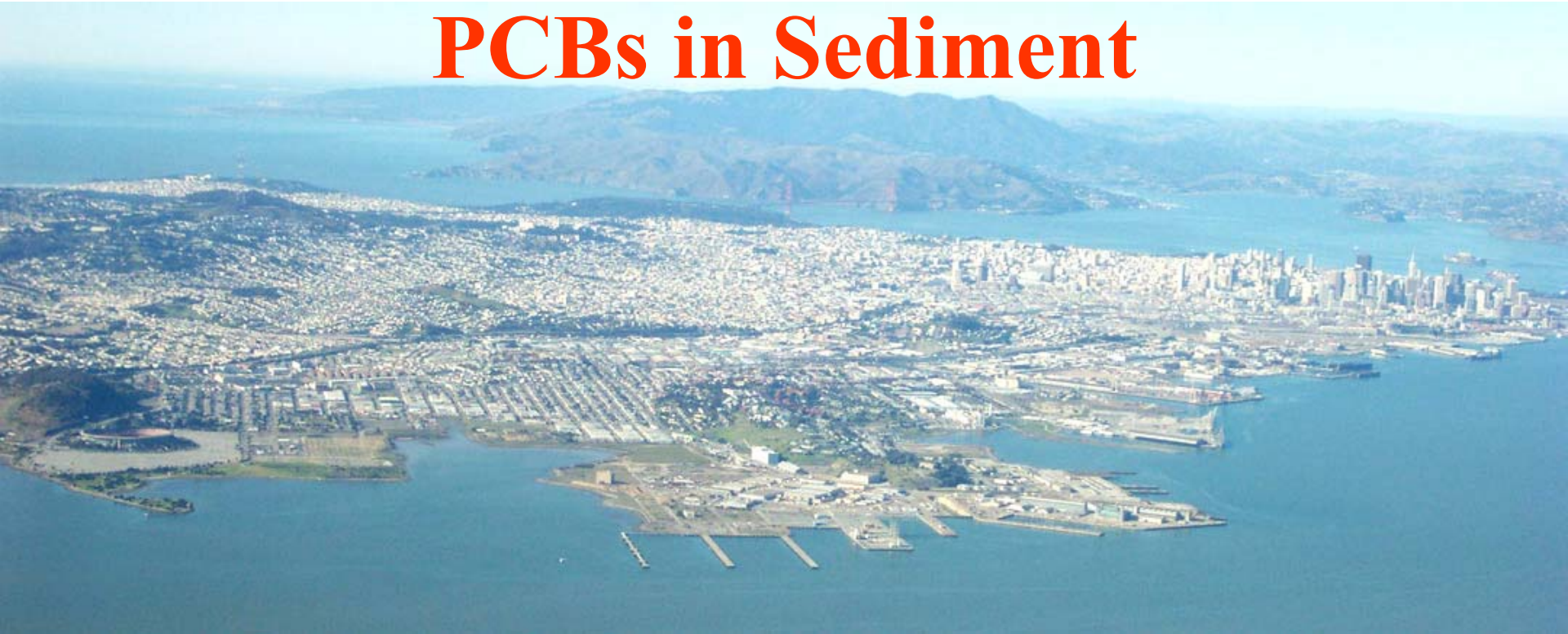


Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment



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Principal Investigators and Performer Organizations

Principal Investigators:

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Upal Ghosh (UMBC)
Todd Bridges, Rod Millward (US Army ERDC)

Performers:

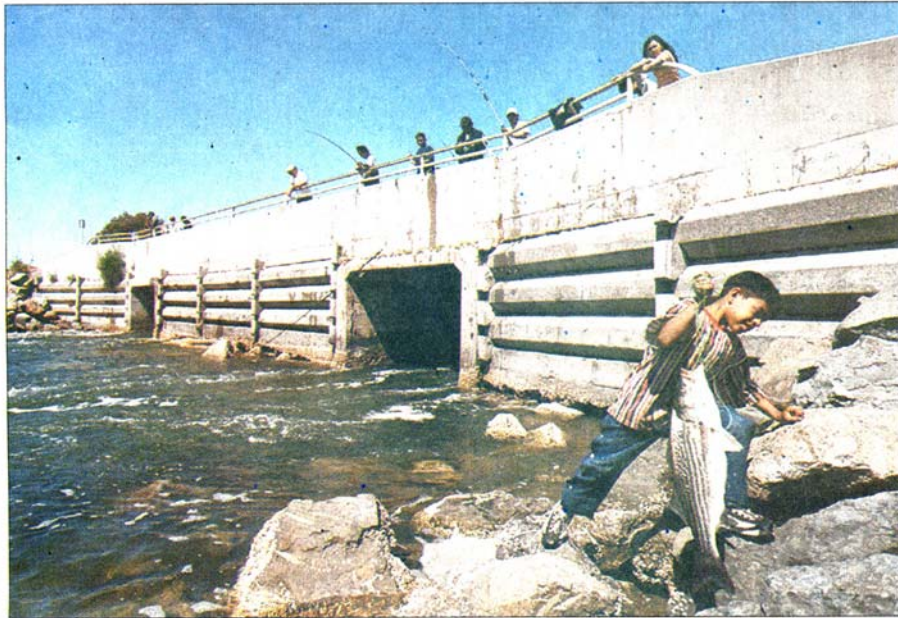
Stanford
Univ. of Maryland Baltimore County
US Army ERDC
Aquatic Environments, Inc.
Williams Environmental Services, Inc.
NAVFAC
NFESC

Non-removal treatment of contaminated sediments

SATURDAY: August 5, 2000

The Peninsula's Hometown Newspaper

Warning: Fishing from the dock of the Bay may be hazardous to your health



Fish are plentiful at the lagoon near state Highway 101 in Brisbane.

JOHN GREEN — Staff

The day's catch is fraught with peril

- Reactive caps
[Anacostia River, Wash. DC]
- Monitored natural recovery
[Lake Hartwell, SC]
- In-situ stabilization
[Hunters Point, SF Bay]

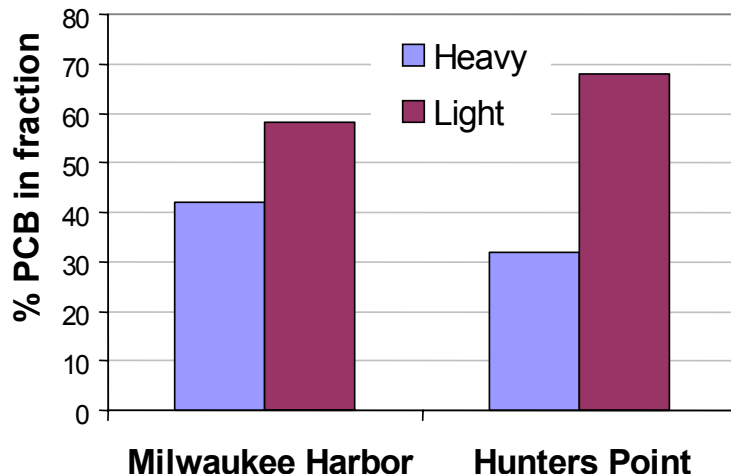
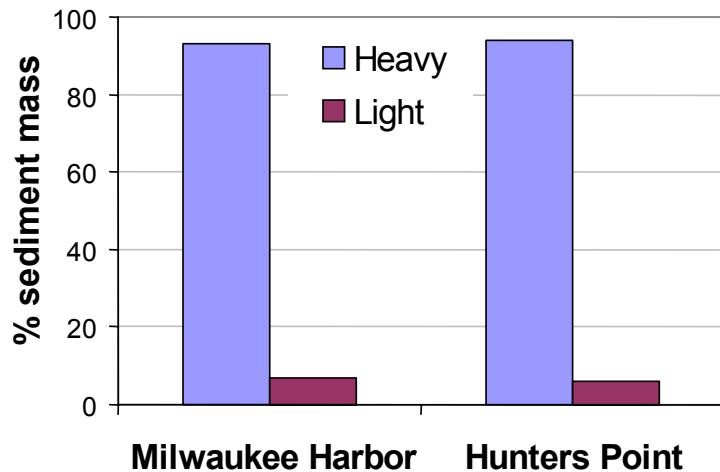
Hunters Point, San Francisco Bay



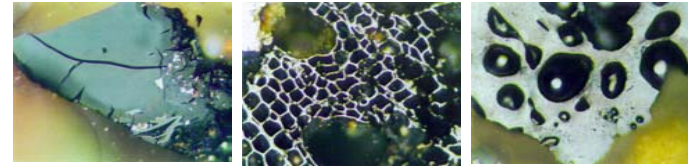
- PCB hot spot, 1-20 ppm
- Inter-tidal zone South Basin



Distribution of PCBs...



5-7% light carbonaceous matter



oxidized coal charcoal coke

PCBs associated with lighter density fraction (~ 60-70%)

Lesson:

Over time PCBs accumulate in coal/charcoal/coke and are more strongly bound and less bioavailable

Link chemistry and bio-uptake



- ***Hypotheses:***

The bioavailability of PCBs, PAHs, & DDT depends on particle type.

We can change bioavailability by adding sorbent carbonaceous particles.



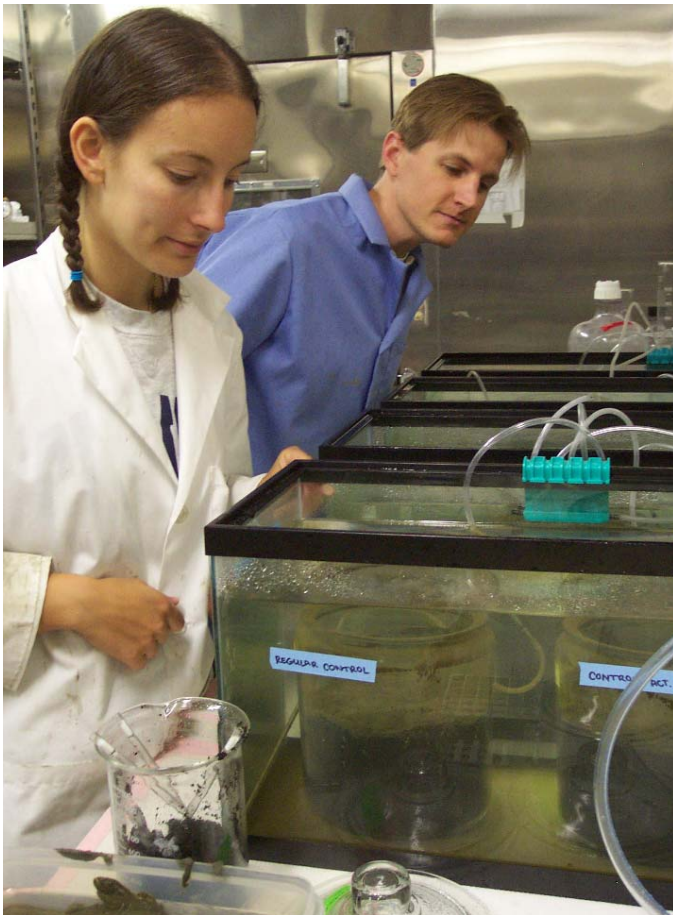
- ***New strategy:***

Management of PCBs using in situ stabilization

Lab testing: SERDP & match funds

- Physicochemical tests:
 - Aqueous equilibration
 - Accumulation in semipermeable membrane device
 - Desorption and flux from sediment
- PCB bio-uptake:
 - Three organisms: amphipod, worm, and clam
 - Two sorbents: coke and activated carbon
 - Variables: dose, contact time, particle size
- PCB absorption efficiency by clams
- Organism survival, growth, reproduction, stress
- Sediment erosion tests using a Sedflume

Bioaccumulation studies



Macoma balthica



Neanthes arenaceodentata



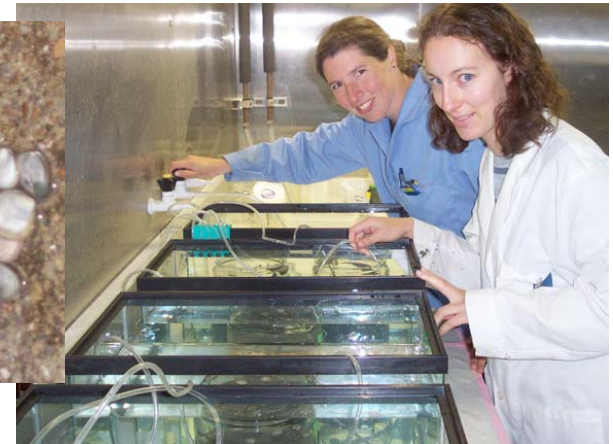
Leptocheirus plumulosus

- Survival, growth, reproduction, activity
- PCB bioaccumulation

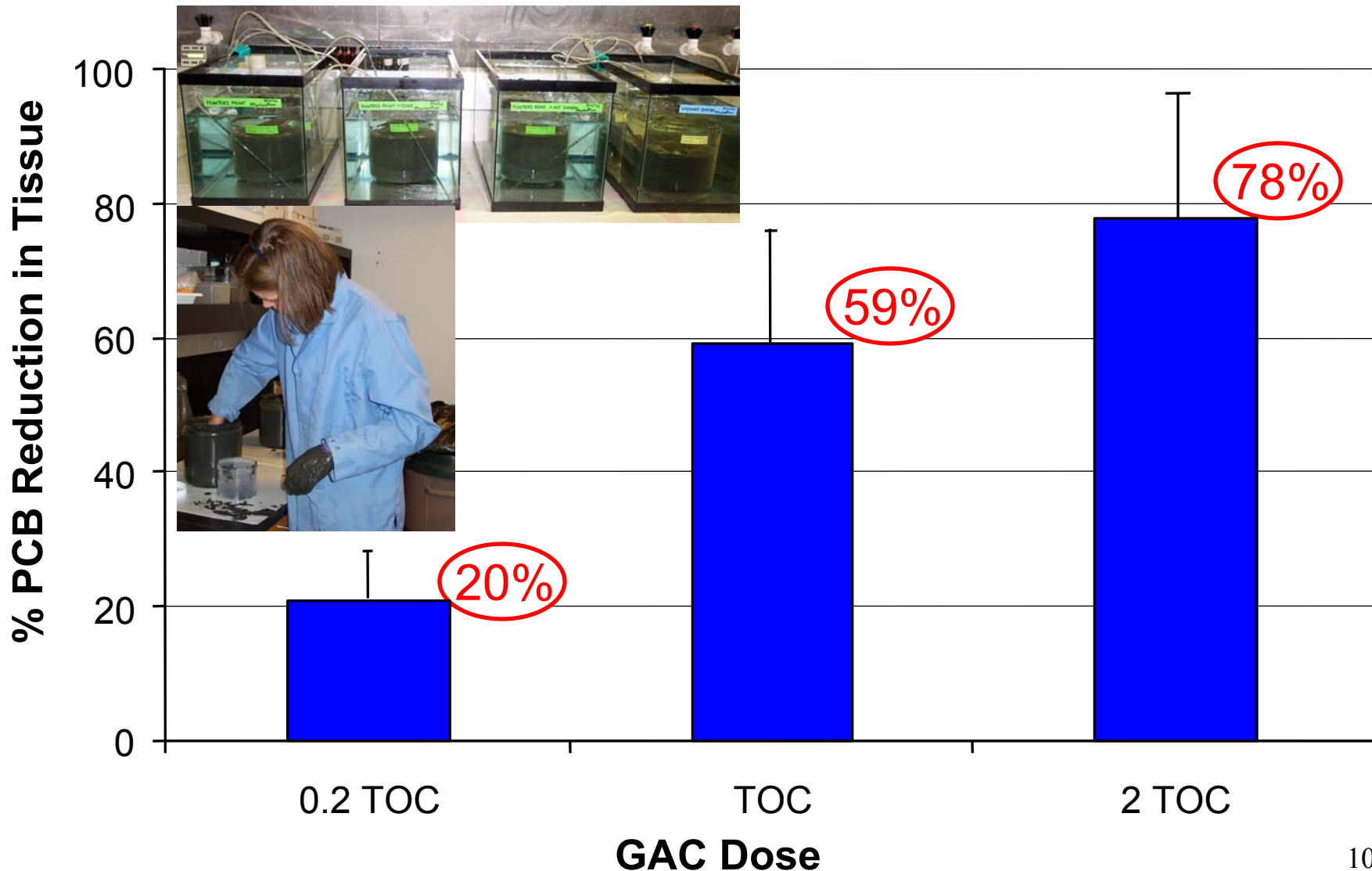
Bioaccumulation studies



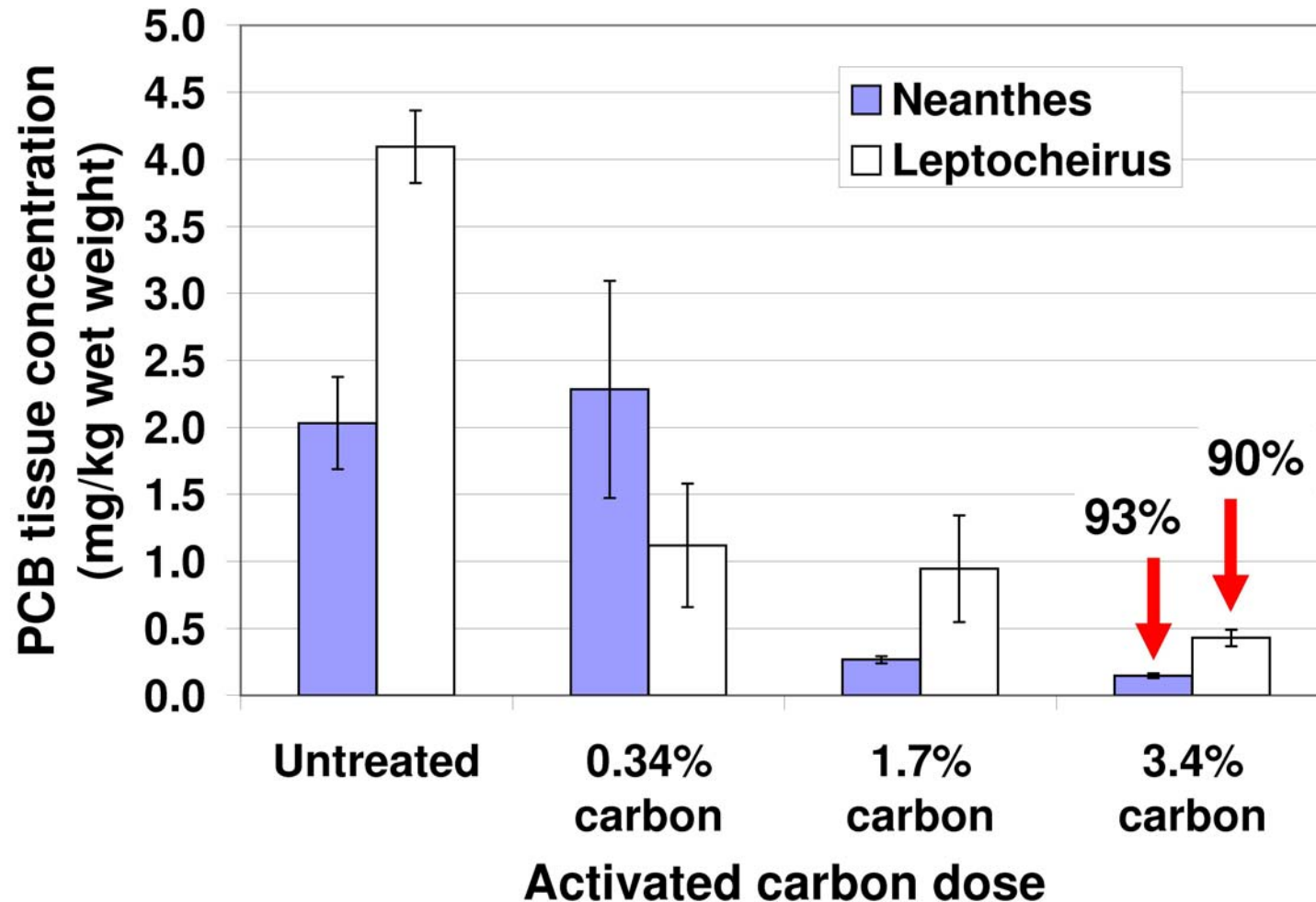
- AC mixed with sediment for 1 or 6 months
- Add organisms and evaluate bio-uptake during 28- or 56-day tests
- Controls: untreated Hunters Point and background sediment



AC dose response... clam



AC dose response...worm & amphipod

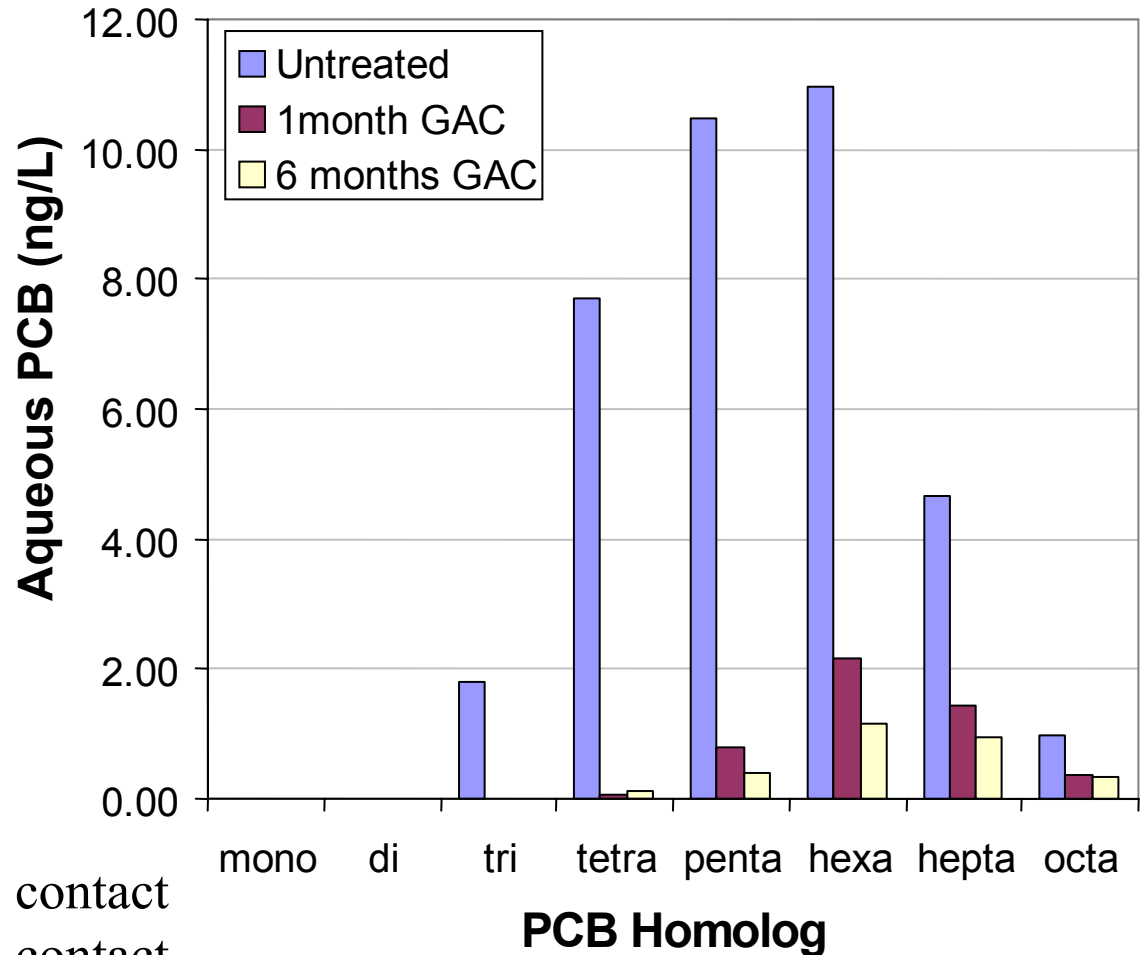


Aqueous equilibrium conc. reduction

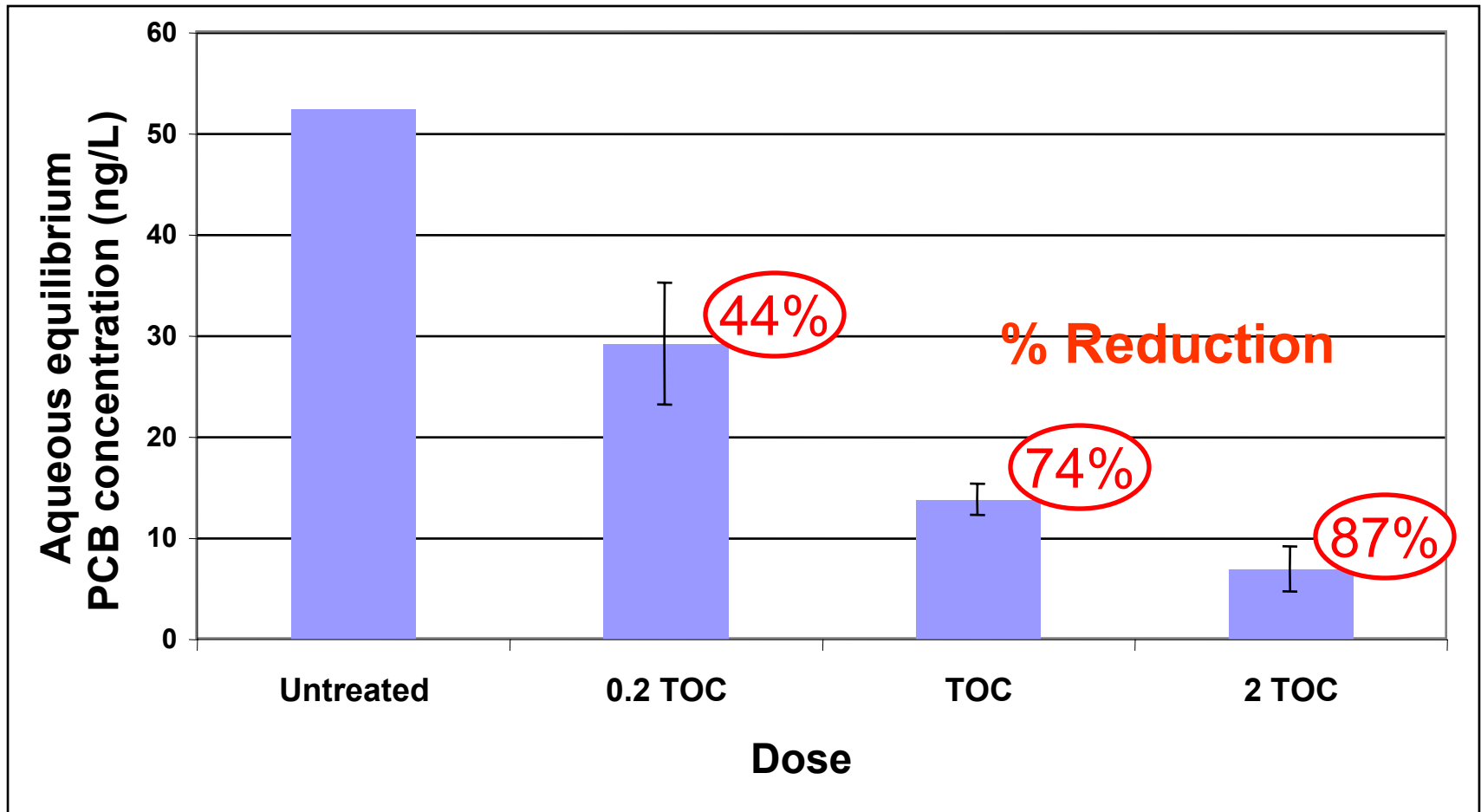


**Alum-flocculation to
remove colloids**

- 87% reduction with 1 mo. contact
- 92% reduction with 6 mo. contact
- More efficient reduction for lesser chlorinated PCBs



AC dose response... aqueous



Sediment erosion tests



- AC is stable in sediment
- Critical shear stress not increased by mixing with carbon

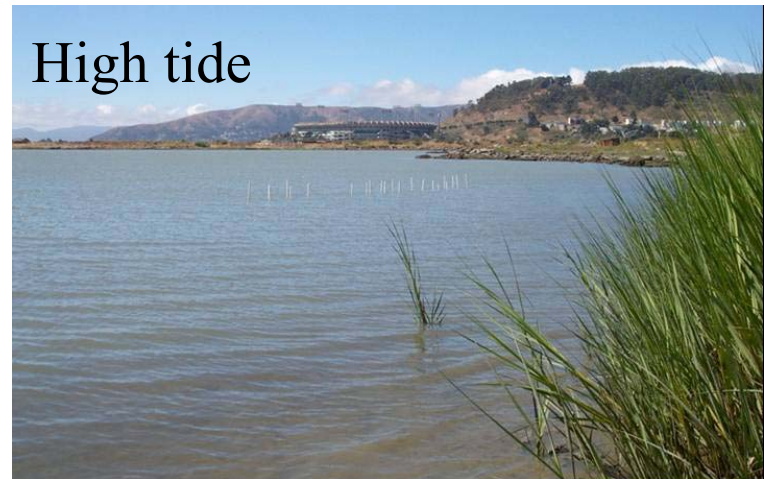
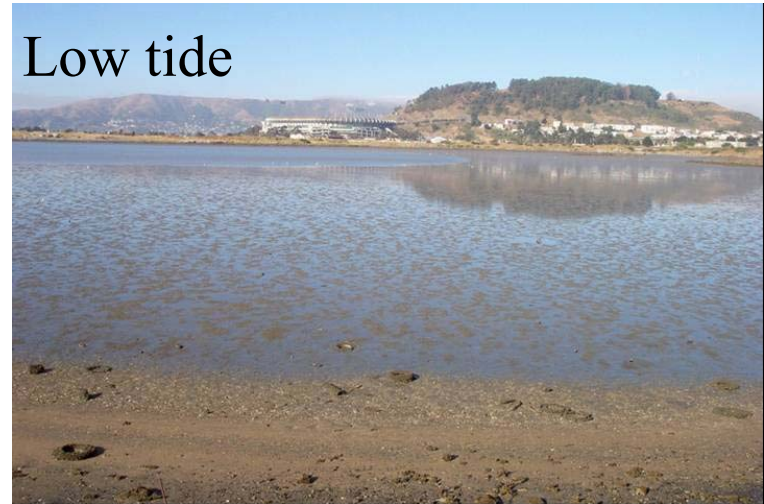


Significant findings

- **PCBs are transferred from sediment to AC**
- **AC - treatment reduces**
 1. PCB bioaccumulation: clam, worm, amphipod
 2. Aqueous PCB concentration
 3. PCB uptake in SPMD
 4. PCB flux from sediment
- **If ingested, PCBs on AC are not absorbed**
- **AC is not eroded out of sediment**
- **Important ‘weight of evidence’**

ESTCP - Field testing challenges

- Sediments are cohesive and deployment of heavy equipment is difficult
- Distribute carbon with good mixing in the top 12 inches
- Minimize sediment resuspension and mobilization
- Field monitoring tools need evaluation



ESTCP Field Approach

- Demonstrate and compare effectiveness of two large-scale AC mixing technologies
- Demonstrate reduced PCB availability
 - Validate PCB bioaccumulation in *Macoma nasuta* clams
 - Assess treatment effects on indigenous benthic organisms
 - Validate PCB stabilization by physicochemical tests
- Evaluate possible sediment resuspension and PCB release
- Coordinate and gain approvals: NAVFAC, EPA, Calif. Water Quality Control Board

Equipment for mixing carbon & sediment

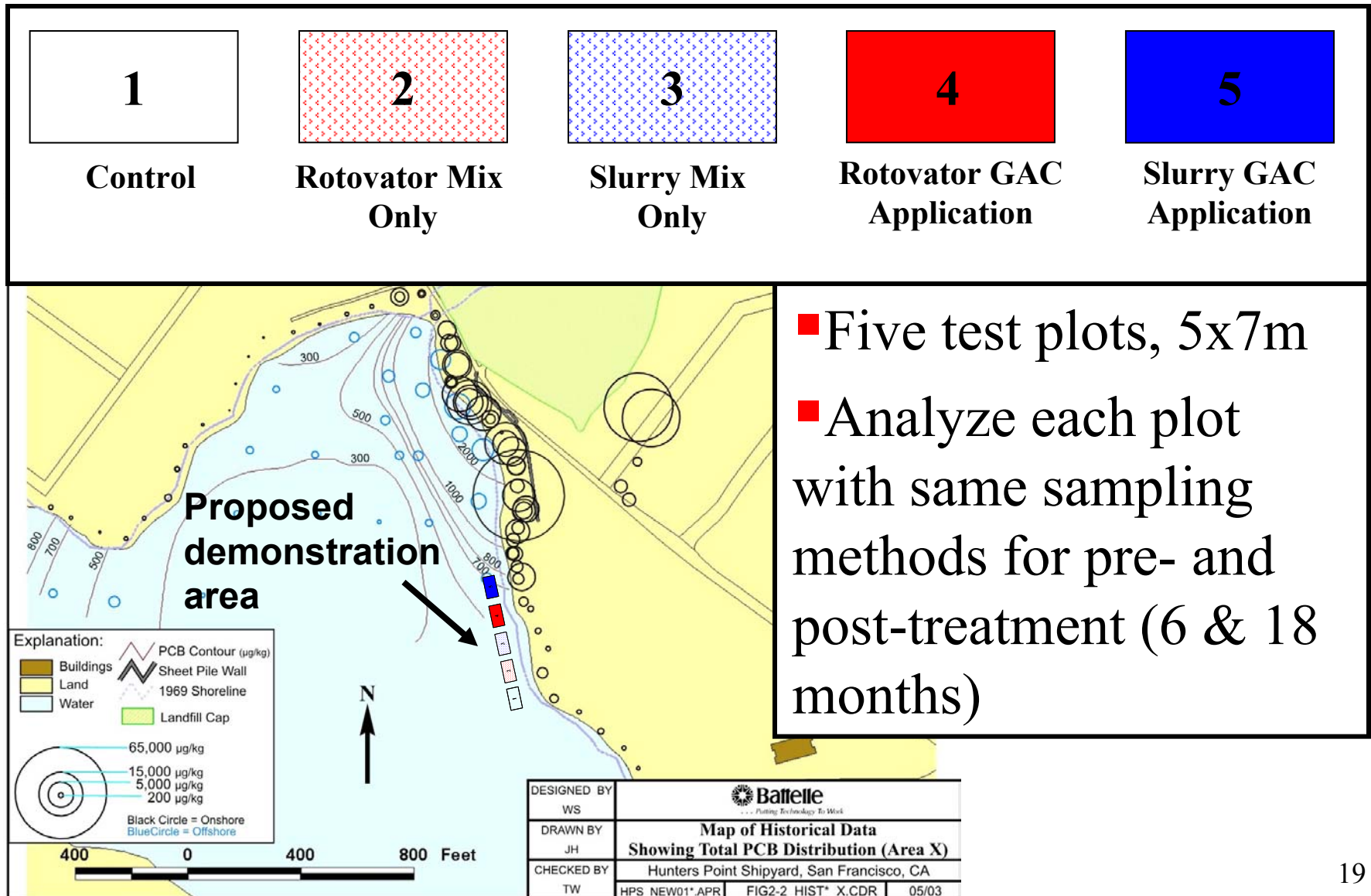


Aquamog: underwater rototiller
(Aquatic Environments, Concord, CA)



Injection system
(Williams Environmental Services,
Stone Mountain, GA)

Test plot design



Field measurements

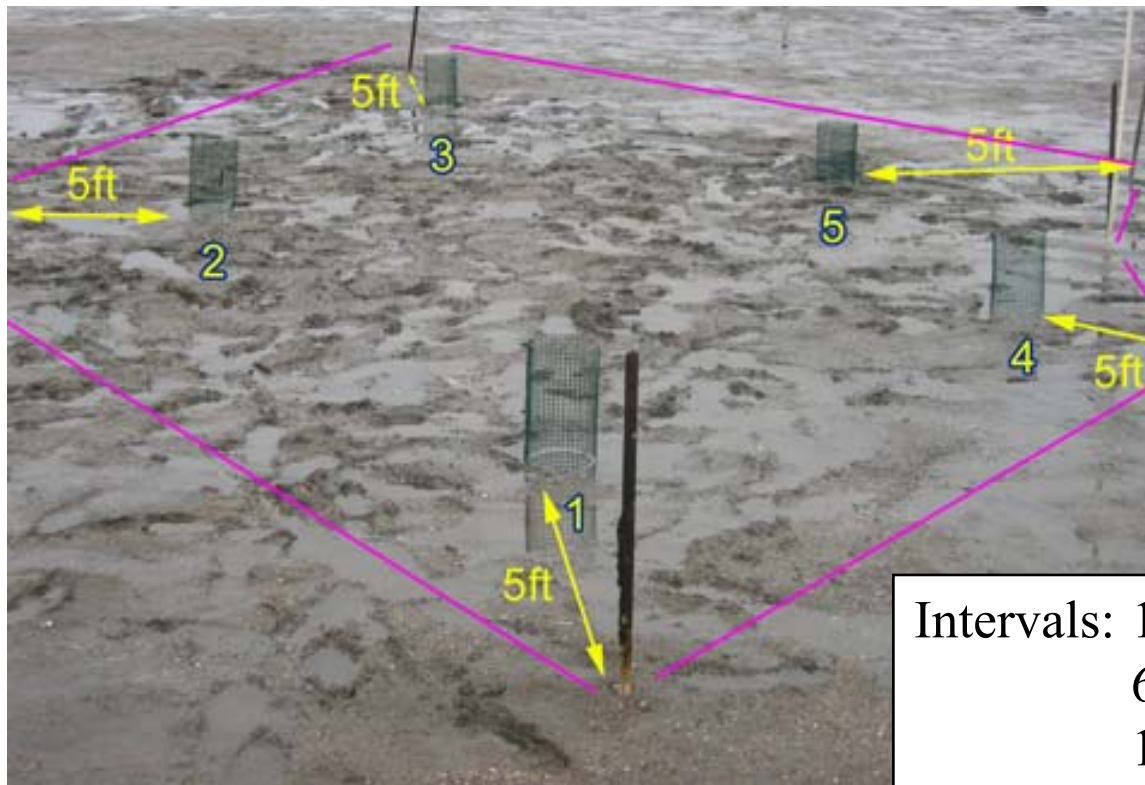
For each plot:

5 tubes (5 clams + 1 SPMD)

5 sediment quadrants (indigenous benthic community)

5 sediment cores

2 overlying water samples



Intervals: 1 mo. Pre-AC
6 mo. Post-AC
18 mo. Post-AC

Measures of success

■ Field measures:

- Homogeneous AC mixing
- Reduced PCB uptake by *Macoma nasuta*
- Reduced PCB uptake by resident *Corophium spp.*
- No detriment to indigenous community structure due to AC application
- Reduced PCB uptake by SPMDs
- Minimal sediment resuspension & PCB release

■ Lab measures:

- Reduced C_{aq}
- Reduced sediment PCB desorption rate



Macoma nasuta
retrieved from clam cages

Preliminary testing: NAVFAC



Ryan Ahlersmeyer, NAVFAC RPM
Leslie Lundgren, Tetra Tech
Patty White, Battelle
Dennis Smithenry, Stanford

- Select mixing equipment and vendors for carbon deployment
- Evaluate procedures for assessment of mixing of AC in sediment in field
- Test clam deployment and monitoring tools
- Work Plan [DQOs, SAP, HASP]

Preliminary testing locations



Hunters Point Initial Testing Locations: July, 2004

Baseline assessment-- monitoring tools



**Sediment coring
Hunters Point, Aug. 2, 2004**

Baseline assessment -- monitoring tools



Deploying Clams, Hunters Point, Aug. 2, 2004
Macoma nasuta

Baseline assessment -- monitoring tools



Retrieving clams and SPMDs, Hunters Point, Aug. 30, 2004

Aquamog and AC Deployments



Pouring AC onto Plot, Hunters Point, Aug. 31, 2004

Aquamog Mixing AC into Sediment



Mixing AC into Plot, Hunters Point, Aug. 31, 2004

Deployment assessment -- Aquamog



Positioning the equipment
and placing carbon

Mixing carbon
with the rotoator



Baseline assessment -- monitoring tools



Suspended solids &
dissolved PCB
measurement over test plot



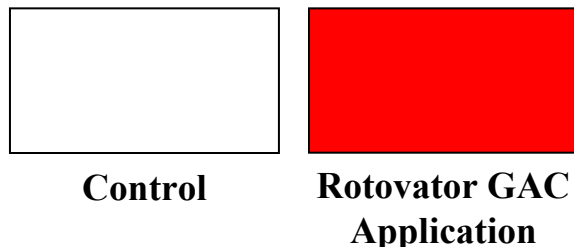
Scope of ESTCP vs. NAVFAC Project

ESTCP



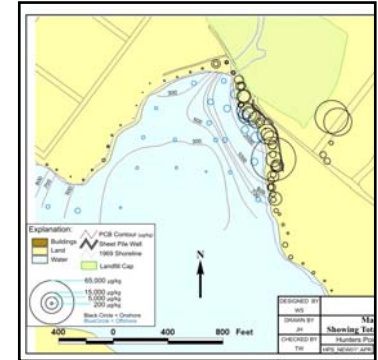
- Five plots [not two]
- Mixing controls [vs. none]
- Two mixing technologies [not one]
- Long-term monitoring [vs. one month]
- Treatment effects on indigenous benthic communities: PCB uptake in amphipods, community structure analysis [not done]
- PCB desorption characteristics with field samples [not done]
- AC deployed mechanically [vs. manual dumping]

NAVFAC



Expected DoD Benefit

For 1,000,000 ft² surface treatment area,
In Situ Stabilization of PCBs with AC (\$0.30—\$2.0/lb)
3.4 wt % AC dose: **\$2—\$9 million**
1.7 wt.% AC dose: **\$1.5—\$5 million**
(\$1 million labor/equipment, depth of 1.5 foot)
Dredging & Disposal: **\$37 million**
(assume \$250/yd³ to depth of 4 feet)



Hunters Point
South Basin

Other contaminated DoD sites:

- Sites with PCBs, PAHs, and DDT
- Tidal Mud Flats (Hunters Point)
- Marshland Areas (Moffett Field Naval Air Station)
- Lagoons (Alameda Naval Air Station)
- Bayou (Tyndall Air Force Base)

Project Milestones

- Two-year project
- Work Plan: Data Quality Objectives, Sampling & Analysis Plan, Health & Safety Plan [Jan 05]
- Field baseline sampling [May 05]
- Equipment deployment & AC mixing [Jun 05]
- Post treatment monitoring [Dec 05 and Dec 06]
- Final report [Mar 07]

Technology Transition Plan

- Peer-reviewed papers
- Technology transfer package (pdfs on web)
- Building upon close coordination with NAVFAC and regulatory agencies
- Presentations at Base Closure Team meetings
- Dissemination to RPMs, Sediments Subgroup of the Risk Assessment Workgroup, RTDF, etc.
- NFESC, Port Hueneme, DoD Service Liaison

Some future questions...

- Use of regenerated AC
- Application to other sites
- Deployment with over-lying water
- Long-term fate of PCBs: e.g., biodegradation
- Long-term ecological monitoring
- AC deployment to allow retrieval at a later date



Acknowledgments

ESTCP Project Performers

- Stanford, Univ. of Maryland Baltimore County, US Army ERDC
- Aquatic Environments, Williams Environmental Services,
- NAVFAC, NFESC



Previous Support and Collaborations

- DoD SERDP, Ford Fund, Schlumberger, NAVFAC, Battelle
- US Geological Survey [Sam Luoma], Sea Engineering [Craig Jones]
- Stanford Bio-X Initiative, Stanford Graduate Fellowship